A New Metric of Image Quality Assessment for Stereoscopic Content

Jesus Jaime Moreno, Alessandro Rizzi, Christine Fernandez-Maloigne

A NEW METRIC OF IMAGE QUALITY ASSESSMENT FOR STEREOSCOPIC CONTENT

Jaime Moreno*, Alessandro Rizzi†, and Christine Fernandez-Maloigne‡
* Escuela Superior de Ingenierıa Mecánica y Eléctrica, Unidad Zacatenco. Instituto Politécnico Nacional, 07738 Unidad Profesional Adolfo Lopez Mateos, Mexico.
† Dipartimento di Informatica, Università degli Studi di Milano, Via Comelico, 39/41 20135 Milano, Italy.
‡University of Poitiers, XLIM Laboratory, CNRS JUR 7252, 11 Bd Marie et pierre Curie, 86962 Futuroscope cedex, France.

ABSTRACT

Automatic or semi-automatic stereoscopic image quality assessment has arisen due to the recent diffusion of a new generation of stereoscopic technologies and content demand. Thereby, there is a growth in asking for algorithms of Stereoscopic Image Quality Metrics (SIQA). In this paper, we present a method for assessing the stereoscopic image quality, QUALITAS. QUALITAS is grounded on some human visual system features such as contrast sensitivity, effect of disparate image quality in left and right images, and distance perception, which do not depend on the images being tested. QUALITAS is defined in five stages. Instead of averaging individual qualities of the stereo-pair, QUALITAS introduces Contrast Band-Pass Filtering on a wavelet domain at both views, namely our algorithm perceptually weights left and right images depending on certain viewing conditions. This paper includes the comparison of 27 Metrics SIQA proposed by 16 authors, which summarizes the work made in this field in the recent five years, on image database LIVE 3D. Some algorithms can be combined with any 2D/Normal Image Quality Assessments (NIQA), giving as a result that QUALITAS was compared against 221 Metrics. QUALITAS obtained the best results in terms of overall performance of correlation coefficients. We conclude all metrics in SIQA-SET are simple modifications of NIQA, which take into account some extra characteristics from the disparity map (usually depth variances). Instead QUALITAS incorporates disparity masking in addition to divide 3D scenario in two parts: background and foreground planes. Moreover QUALITAS employs a contrast band-pass filtering, so dynamic parameters are considered as observational distance. It includes loss of correlation, luminance and contrast distortion. It takes into account the visual differences between left and right images, employing a penalization depending on their wavelet energy. Thus, the novelty of QUALITAS lies in combining some the best features of stereoscopic image quality assessments.

KEYWORDS: Stereoscopic image quality, Quality assessment databases, 2D image quality.

INTRODUCTION

Figure 1 depicts a general scheme of stereoscopic imaging, which is divided in three blocks objective assessment (in green), subjective assessment (in blue), and strength of relationship (in red). Objective assessment is a subsystem constituted by the following

parts:
1) Input: Left and right images.
2) Process: Stereoscopic coding.
3) Output: Stereoscopic image.
4) Feedback: Stereoscopic image quality assessment (SIQA).

Bertalanffy in [1] proposed the general systems theory, which describes that Feedback verifies how efficient the Process is. So, the main goal of the SIQA is to measure in the stereoscopic image either image quality or degradation of the original stereo-pair whereas for the process of stereoscopic Coding is to obtain the least possible degradation of the original stereo-pair. In other words, any kind stereoscopic image coder employed in 3D Cinema, for instance, needs to support its results using a SIQA. This lead us to mention that the recent growth of stereoscopic algorithms goes hand in hand to the growth of the way to predict its quality. Thereby, the algorithms that assess the quality of a stereoscopic image has gained great importance.

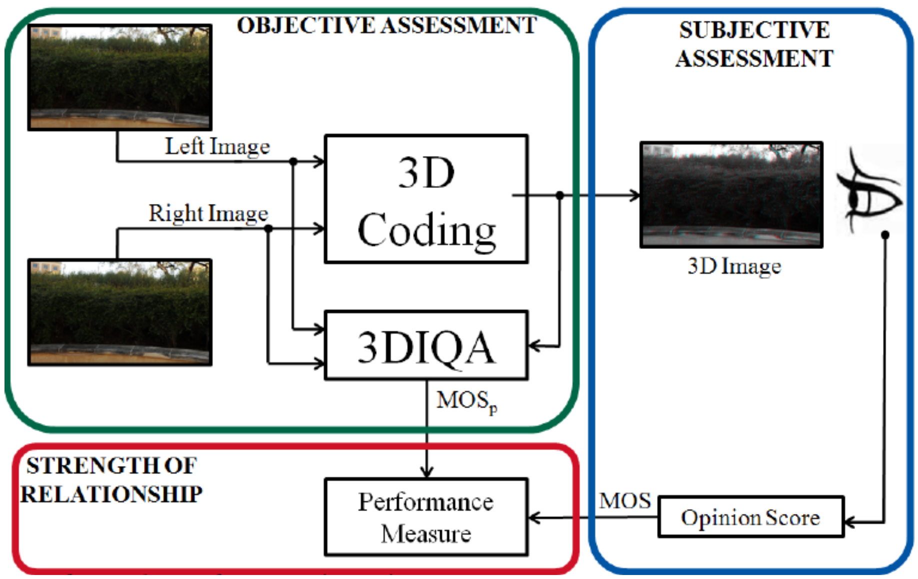

Figure 1. Block diagram of a general system for stereoscopic assessing.

It is reasonable to base SIQA from NIQA, since the observers employed in psychophysical experiments or subjective assessments [2], [3], [4] evaluate image quality from different slices in 2D scenario, which depend of the apparent distance.

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OBJECTIVE ASSESSMENTS

From Figure 1 (green block, Objective Assessment), the main goal of any the stereoscopic image quality is to predict a subjective response, namely finding a predicted MOS (MOSp). Then, Table I shows the 27 stereoscopic metrics from 16 authors, this set of 27 metrics will be call henceforth SIQA-SET. It is worth noting that some authors propose more than one metric and we maintain the metric name that they gave them. Thus, we eventually will refer to a certain metric by the name that appears in the corresponding row, not by its author. Also, SIQA-SET was coded ourselves in MatLab.

Table 1. Stereoscopic image quality assessments.

Algorithm	Metric
Akhter et al. [4]	$AkMOS_p$
Benoit et al. [5]	d_1 d_2 d_3 Ddl_1
Bosc et al. [6]	Q_s
Chen et al. [7]	C_m
Gorley et al. [8]	$SBLC$
Gu et al. [9]	$ODDM_4$
Hewage et al. [10]	$PSNR_{edge}$
Jin et al. [11]	MSE_{ms} MSE_{dp}
Joveluro et al. [12]	PQM_{3D}
Mao et al. [13]	Q_{mao}
Shao et al. [14]	Q_{shao}
Shen et al. [15]	$HDPSNR$
Solh et al. [16]	$3VQM$
Yang et al. [17]	IQA SSA
You et al. [18]	$YouDMOS_p$ OQ DQ_{map_1} DQ_{map_2} DQ_{map_3}
Zhu et al. [19]	e_i

SUBJECTIVE ASSESSMENTS

In the field of subjective stereoscopic image quality assessment, few image databases have been developed. We have employed LIVE 3D stereoscopic image database of the Laboratory for Image and Video Engineering of the University of Texas at Austin (USA. LIVE 3D contains standardized psychophysical experiments [40] and their stereoscopic images quality data are based on observer opinion score, collected with individual quality judgments, in Figure 1 the blue block Subjective Assessment). In each trial, the images are rated on a scale of excellent, good, fair, poor, and bad. Then, by means of statistical procedures, the data are processed, finally obtaining the mean opinion scores (MOS). Each stereoscopic image database applies different statistical procedures; the reader can refer to the citation for the details. Additionally, MOS merges results of different types in a form that allows the comparison with any kind of stereoscopic assessment metric. Since SIQA predicts subjective responses, namely it obtains a predicted MOS or MOSp.

EXPERIMENTAL RESULTS

From Figure 1 red block, strength of relationship between normalized MOS and MOSp is measured by a Performance Measure (PM), such as correlation coefficient. Strength of relationship gauges how strong is the tendency of two variables to move in the same or opposite direction. The performance measures used are:

- Spearman's Rank Ordered Correlation Coefficient (SROCC),
- Kendall's Rank Ordered Correlation Coefficient (KROCC),
- Pearson's Linear Correlation Coefficient (LCC) and
- Root-Mean-Squared Error (RMSE).

Any correlation coefficient value close to 1 indicates good correlation with human perception, while lower values of RMSE indicate better performance.

Table 2 shows the performance of an overall experimental result, which includes all SIQA of the SIQA-SET in addition to QUALITAS. Thus, QUALITAS correlates in 93.92% and 76.68%, Figure 11, being the metric that obtains the best LCC and KROCC, respectively. In terms of SROCC, the best ranking metric is d2 UQI, since it is best with 93.35%. Also, based on these results, DQmap2 is the most accurate metric not only for all set of distortions considered but also for JPEG2000 and JPEG distortions. Regarding only these image compressiondistortions, QUALITAS is the best ranking metric in both distortions obtaining the highest correlation in both rank ordered coefficients.

Table 2. Overall performance across SIQA-SET including QUALITAS in predicting perceived stereoscopic image quality.

Distortion	SIQA	NIQA	PM	Value
ALL	QUALITAS	none	LCC	0.9392
	d_2	UQI	SROCC	0.9335
	QUALITAS	none	KROCC	0.7668
	DQ_{map_2}	none	RMSE	0.1289
JP2K	QUALITAS	none	LCC	0.9467
	QUALITAS	none	SROCC	0.9126
	QUALITAS	none	KROCC	0.7443
	DQ_{map_2}	none	RMSE	0.0961
JPEG	d_2	UQI	LCC	0.7620
	QUALITAS	none	SROCC	0.7384
	QUALITAS	none	KROCC	0.5396
	DQ_{map_2}	none	RMSE	0.0742
WN	QUALITAS	none	LCC	0.9333
	d_2	MSSIM	SROCC	0.9425
	d_2	MSSIM	KROCC	0.7911
	d_1	BRISQUE	RMSE	0.1001
Blur	d_2	UQI	LCC	0.9558
	MSE_{ms}	none	SROCC	0.9318
	$YouDMOS_p$	AD	KROCC	0.7818
	$PSNR_{edge}$	NAE	RMSE	0.1156
FF	QUALITAS	none	LCC	0.8684
	QUALITAS	none	SROCC	0.8256
	QUALITAS	none	KROCC	0.6371
	d_2	BPSNR	RMSE	0.1116

CONCLUSIONS

This paper includes the comparison of 27 Metrics SIQA proposed by 16 authors, which summarizes the work made in this field in the recent five years. Some algorithms can be combined with any NIQA, giving as a result that QUALITAS was compared against 221 Metrics.

QUALITAS obtained the best results in terms of overall performance of correlation coefficients either LCC, SROCC or KROCC with 93.92%, 93.34% (just 0.01% below the best one), and 76.68%. For Root Mean Squared Error, QUALITAS did not get the best results, because it was developed with the aim of increasing any kind of correlation coefficient at certain times sacrificing accuracy.

We conclude all metrics in SIQA-SET are simple modifications of NIQA, which take in to account some extra characteristics from the disparity map (usually depth variances). Instead QUALITAS incorporates disparity masking in addition to divide 3D scenario in two parts: background and foreground planes.

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